SENIOR CAPSTONE/ SENIOR DESIGN EXPERIENCE

2025

Modular Crop Scouting System

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Executive Summary

This project adds value to an existing Polaris NorthStar research vehicle by integrating a modular crop scouting system. The system captures high-resolution, geo-tagged images to support in-season crop monitoring and improve data consistency. Designed to be lightweight, cost-effective, and easily mountable, it reduces manual scouting labor and enhances research efficiency. Field testing confirmed image clarity over 5 mph, with sponsor feedback guiding future improvements in image organization and shutter speed performance.

Project Research and Context

Traditional crop scouting is time-consuming and inconsistent. Research showed a need for automated, mobile image collection in the field, especially one that could integrate easily with existing research platforms. Existing technologies often lacked portability, modularity, or ease of deployment. This project addresses that gap with a rugged, GPS-enabled camera system mounted on a Polaris NorthStar. The final deliverables include a stable imaging setup, a modular mounting frame, CAD models, and field-tested performance data. Safety codes and standards such as UL 61010-1, SAE J1171, and ANSI Z535.4 were considered throughout the design and integration process to ensure reliable and secure operation.

Project Characteristics and Limits

Criteria:

- Cost
- Durability
- Image Quality
- Modularity

Constraints:

- ≤ 50 lbs total system weight
- ≤ $1,000 total cost
- Stable mounting during operation
- Minimal vehicle modification

Solution Ideas and Selection

Initial concepts included a Modular 2-Camera System, Modular 3-Camera System, and a system using the Data Speed Camera. After evaluation, a roof-mounted camera system was selected for its image stability and compatibility with field conditions. It integrates GPS for image tagging and uses clean, protected wiring through the vehicle. The images below in *Figure 1,* show the ideas that were not selected.

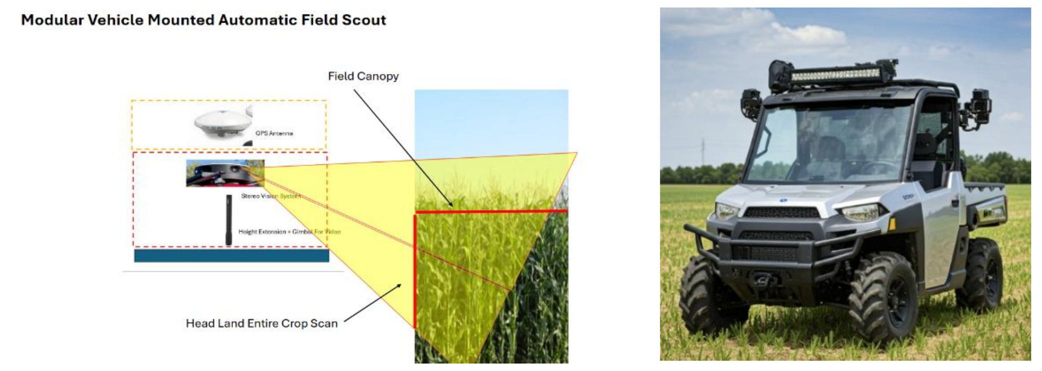

Figure 1: CAD models and Prototype Solutions

Value Proposition

This project enhances the functionality of the Polaris NorthStar by enabling researchers and ag professionals to collect high-quality field data with less effort. The system improves consistency, saves time, and is adaptable for various crops and research needs. Images are geo-tagged for easy reference to crop locations (Figure 2). Risks such as motion blur and weather exposure are being addressed in future updates.

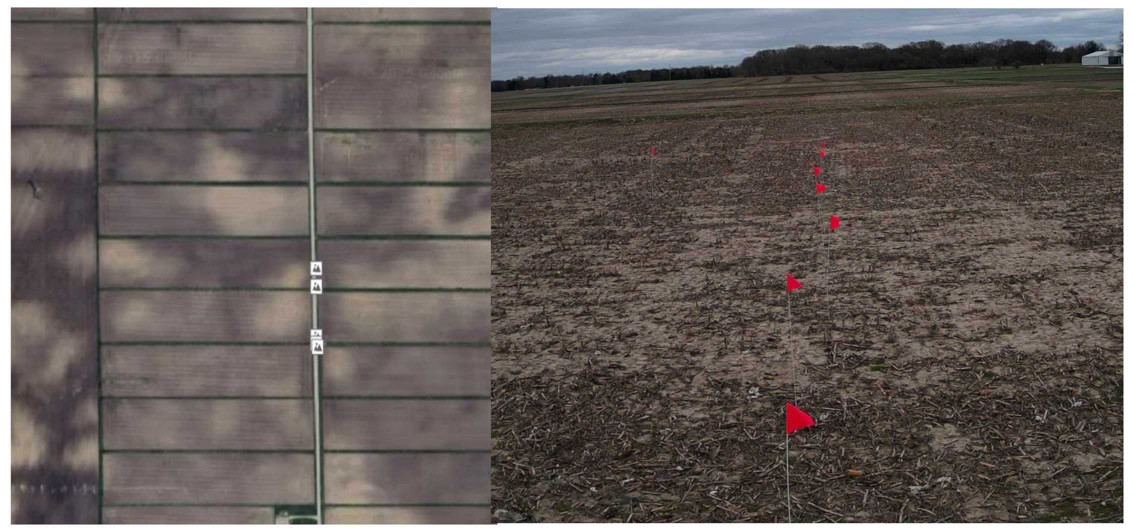

Figure 2: Geo-tagged imagery

Figure 3: Final Product

Design and Development

The system features a roof-mounted camera to provide maximum field visibility. A custom frame, secured with U-bolts, allows for quick installation and removal. Wiring runs through the vehicle's headliner using protective grommets to protect connections and keep the interior clean. The onboard GPS module tags each image with location data to support spatial analysis. The overall setup was designed to remain stable during vehicle motion, lightweight to meet the 50 lb limit, and modular for use with other platforms. CAD tools were used to model the frame and assess mounting angles, and multiple versions were prototyped before final installation. Blur metrics (*Figure 5*) were used to evaluate image quality, with values over 1000 indicating clear and gradient images suitable for research analysis. The team also utilized a Gantt chart (Figure 4) to stay on track with the design timeline.

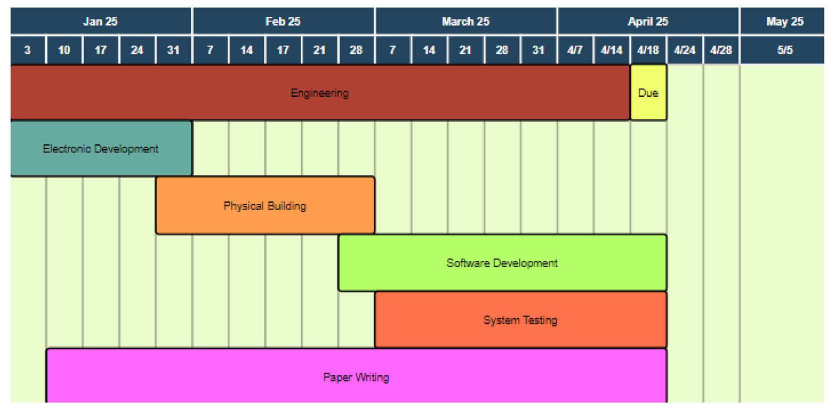

Figure 4: Gantt chart

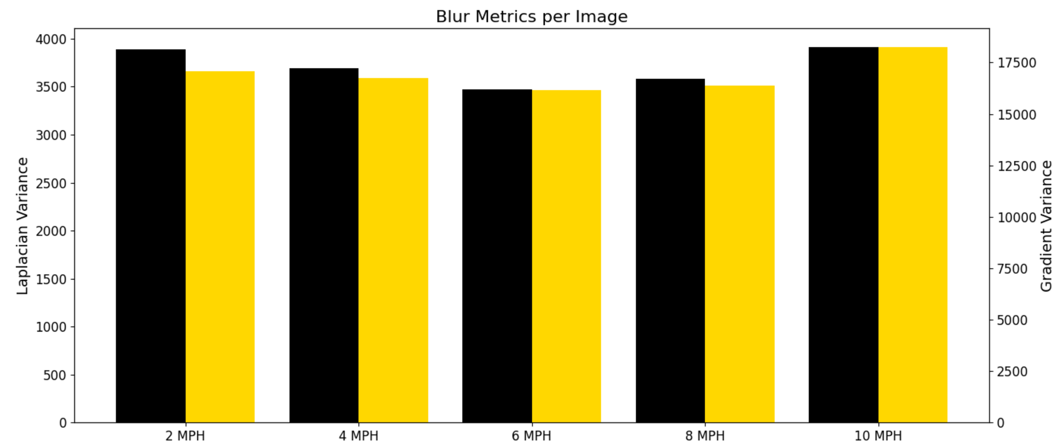

Figure 5: Blur Metrics

Testing and Feedback

Field tests were conducted at speeds ranging from 0 to 10 mph to evaluate the image clarity threshold. Figure 6 shows the image blur testing results, demonstrating sharp images up to 10 mph. Figure 7 displays the prototype setup and FEA validation results, which confirmed structural integrity under operational loads.

The mounting system-maintained level positioning during motion, verified through horizon analysis of captured images. Environmental testing confirmed short-term durability in dusty and lightly wet conditions, while GPS data was consistently logged and matched with each image.

Sponsor feedback highlighted the system's clean integration, quick installation, and Polaris compatibility. Recommendations included testing higher frame rate cameras and improving file management automation - both planned for future implementation.

Figure 6: Image resolution based on distance of corn plant

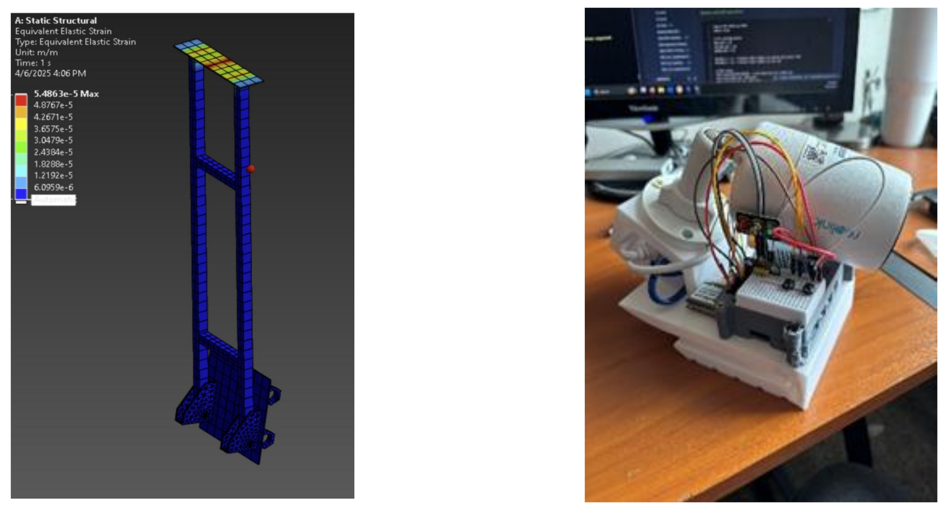

Figure 7: FEA testing and prototype used

Future Impact

The team will prioritize automating image transfer workflows, enhancing weatherproofing for extended field durability, and conducting expanded validation testing across additional crop varieties, with the ultimate objective of developing a scalable, turnkey solution that can be rapidly adapted to diverse agricultural environments. These targeted improvements will address current operational limitations while positioning the system for widespread commercial adoption across different field conditions and farming applications.

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